Maine Geological Survey:
Recent and on-going water resources studies

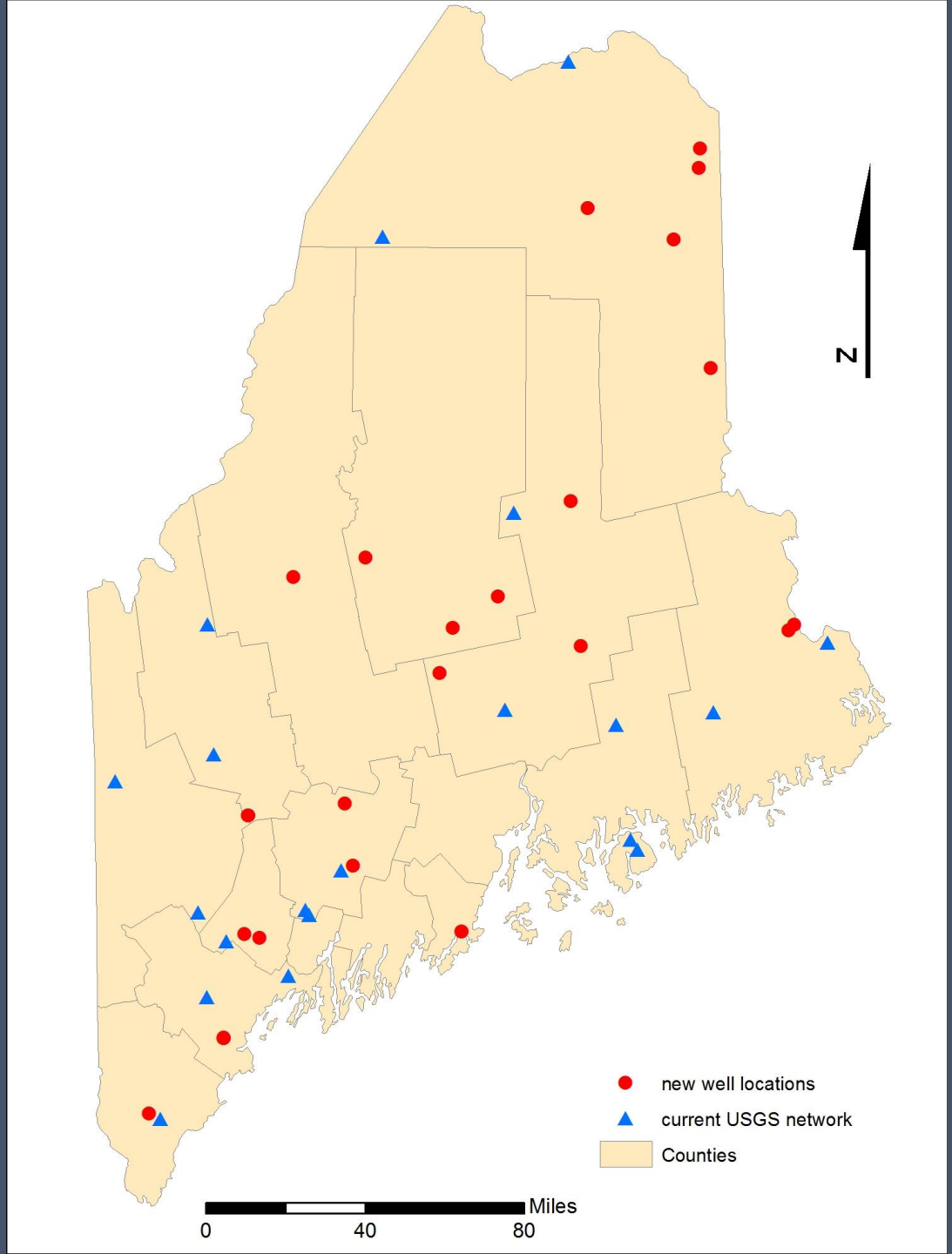
1. National Groundwater Monitoring Network (NGWMN)
2. Statewide Recharge Model using a Soil Water Balance (SWB)
3. USGS Water Census and Water-Use Data and Research (WUDR)
4. Agriculture water use survey and irrigation demand model

National Groundwater Monitoring Network (NGWMN)

USGS Cooperative Agreement to improve the groundwater level network in Maine

Current Water Level Monitoring Wells

- The USGS maintains only 18 monitoring wells in Maine.
- 2018: MGS participation in the NGWMN program added 32 new wells at 22 sites.
- All new wells are at DEP monitored sites.

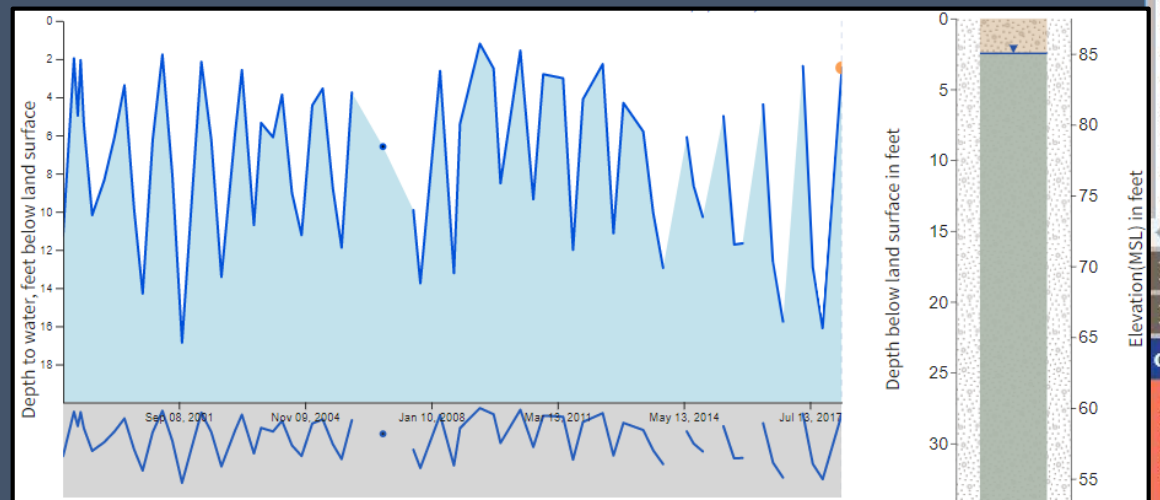


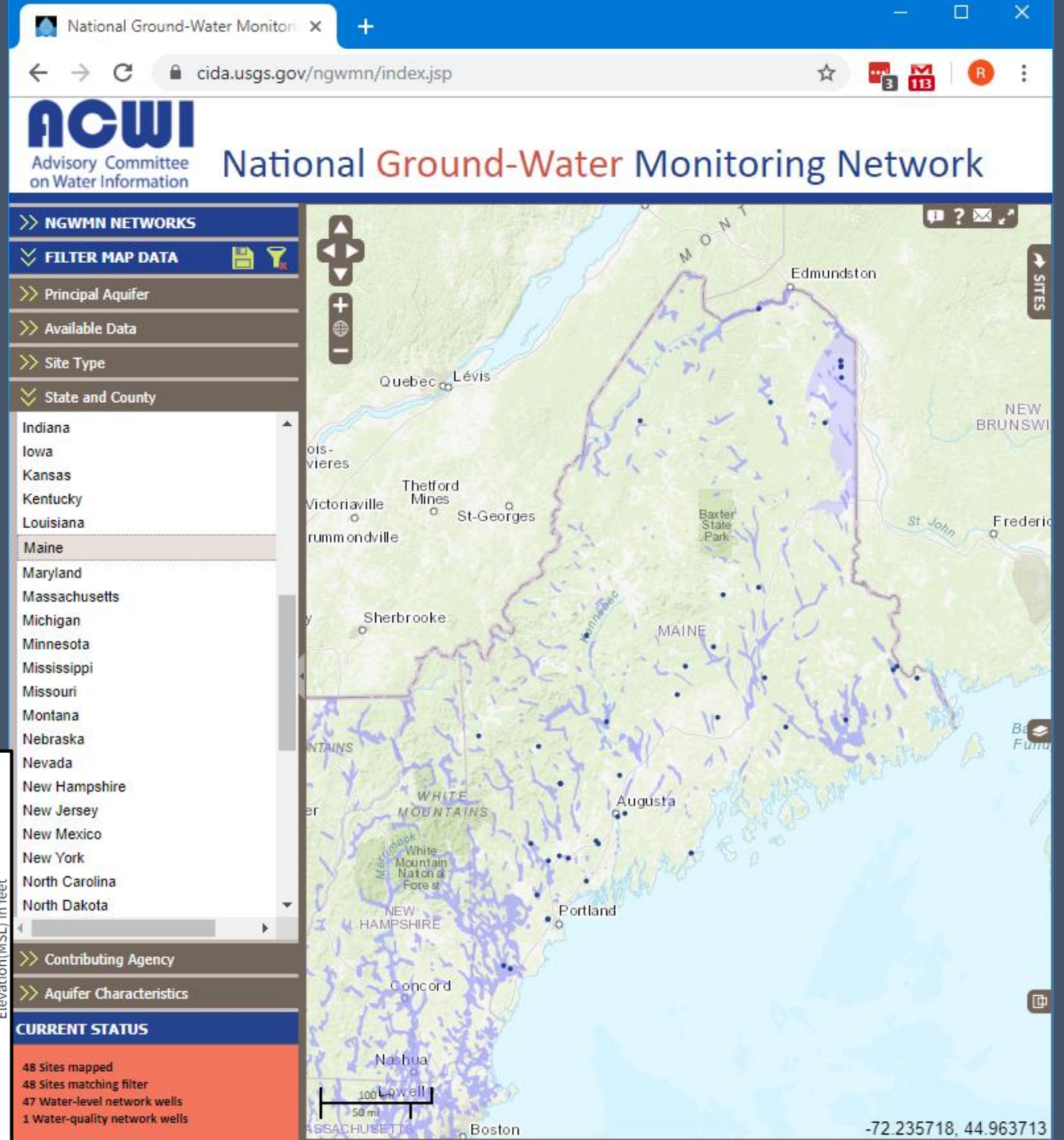
NGWMN Portal

cida.usgs.gov/ngwmn/

Available data:

- Water levels (10+ years)
- Location and elevation
- Lithology and well construction details
- …and more!





2019: Information gap filling for Maine's NGWMN network

Information that is required or desired for the National network was missing from many well records

- Visited 29 wells at 21 sites
- Documented measuring points, access, and construction details
- Measured water levels, total depths, casing dimensions
- Collected survey-grade GPS coordinates:
  National network benefits from high-accuracy elevations in a consistent national datum (NAVD 88)

2020: Future work for the NGWMN

We will again visit the wells to perform a downhole camera survey:

- Record screen and casing details
- Assess the condition and function of wells
- Observe fracture patterns and lithology in bedrock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USGS Recharge Model using the Soil Water Balance (SWB)

Statewide gridded estimates of groundwater recharge have been released

Recharge model development

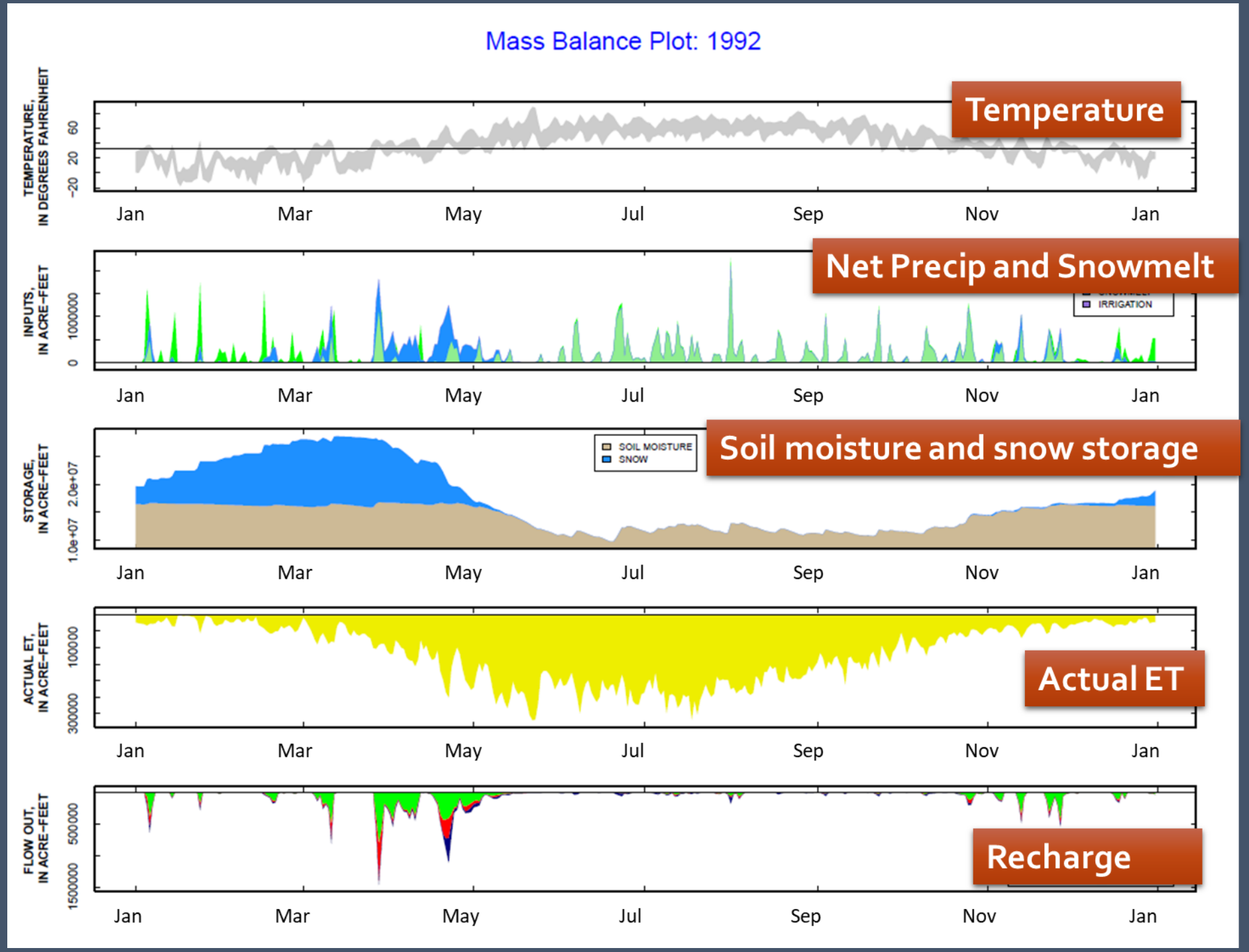
Martha Nielsen (USGS) has been working on this project since 2015:

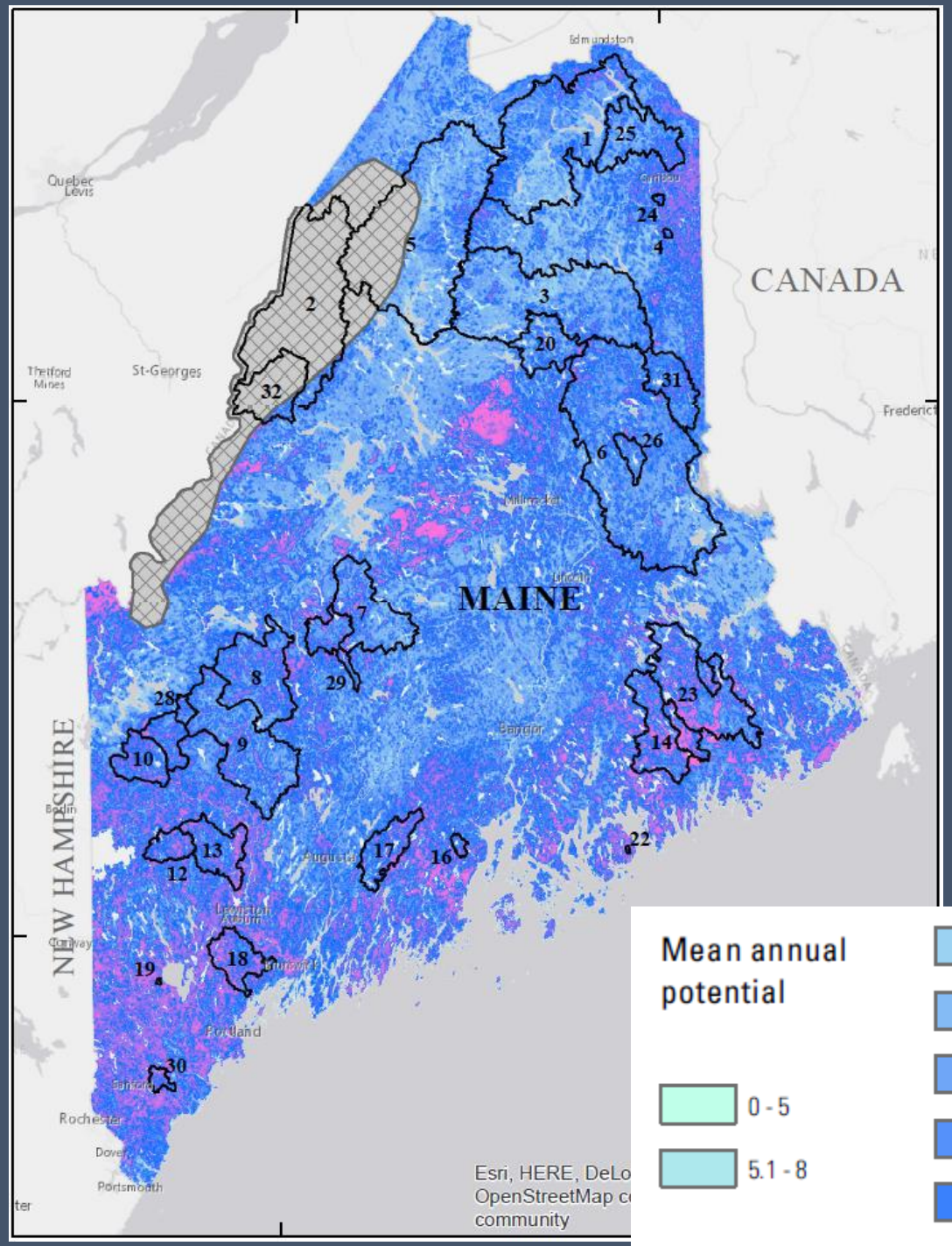
- Selection of Soil Water Balance (SWB) model
- Pilot development and calibration
- Statewide development
- Calibration to gauged, unregulated river basins
- Monte Carlo uncertainty analysis

Calibration and Monte Carlo were run on the HTCondor parallel computer cluster at the USGS Wisconsin office

USGS Soil Water Balance (SWB) Model

- A climate-based water balance model for estimating potential groundwater recharge
- Statewide, grid-based calculations
- Calculates snowmelt, direct runoff, evapotranspiration, snow and soil moisture storage
- Calculates infiltration beyond root zone (potential recharge)
- Output is a 250-m grid of annual total potential recharge

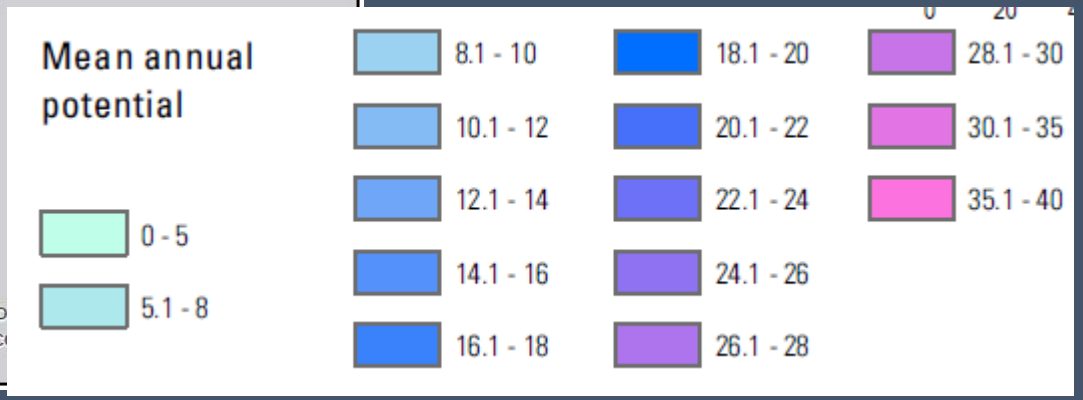

Mass Balance Plot: 1992
TEMPERATURE, IN DEGREES FAHRENHEIT
-20
20
60
Temperature
Jan
Mar
May
Jul
Sep
Nov
Jan
INPUTS, IN ACRE-FEET
0
1000000
IRRIGATION
Net Precip and Snowmelt
STORAGE, IN ACRE-FEET
1.0e+07
2.0e+07
SOIL MOISTURE
SNOW
Soil moisture and snow storage
ACTUAL ET, IN ACRE-FEET
300000
100000
Actual ET
FLOW OUT, IN ACRE-FEET
1500000
500000
Recharge

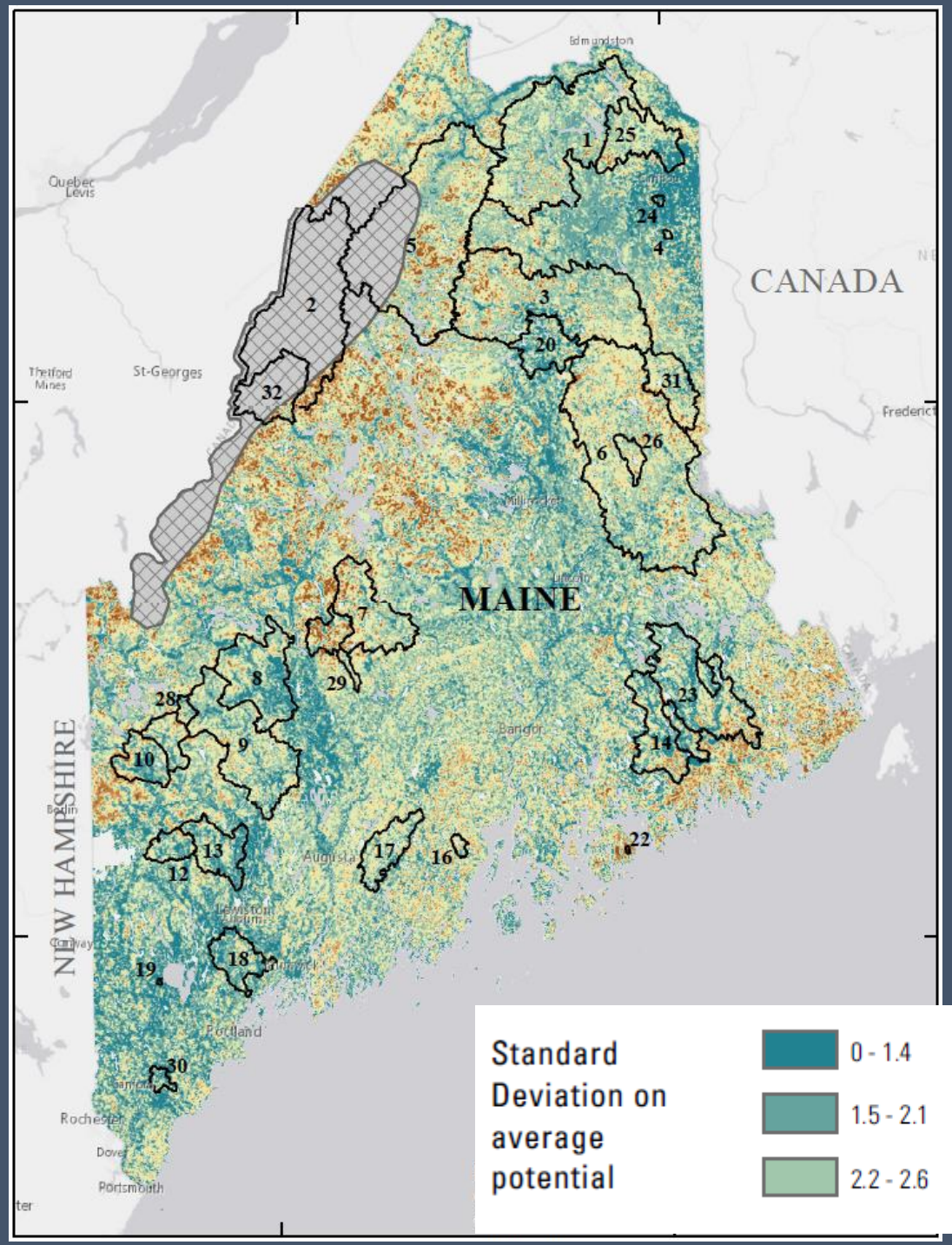


25-year (1991-2015) Mean annual potential recharge

250-m grid

Provisional Data





Uncertainty grid: Standard Deviation of all Monte Carlo Runs

250-m grid

Provisional Data

Final datasets have been released:

Nielsen, M.G., and Westenbroek, S.M., 2019, Simulated 25-year potential recharge datasets for Maine, 1991-2015: U.S. Geological Survey data release, https://doi.org/10.5066/P9052ULY.

Final report will be available online very soon.

Water-Use Data and Research (WUDR) program

Program to help states help the USGS – 5 year National Water Census

MGS is currently in the second of two USGS Cooperative Agreements

Water Use Data and Research (WUDR) Program

MGS projects funded by the USGS program:

- 2016: Development of our Water Use Workplan
- 2017-2018: Cooperative grant on agricultural water use
- 2019-2020: Cooperative grant on domestic water use

Agricultural water use survey and irrigation demand model

Part 1: Survey results have been published in MGS Circular 18-9

Part 2: Gridded estimates of irrigation water demand have been produced

Ag Part 1:

CIRCULAR NO. 18-9

Title: *Survey of Agricultural Water Users in Maine: Results for Calendar Year 2016*

Author: *Ryan P. Gordon, Amber H. Whittaker, and Robert G. Marvinney*

Date: *May 2018*

Survey response rate

County	farms contacted	total survey responses	response rate
Androscoggin & Sagadahoc	212	54	25%
Aroostook	207	43	21%
Franklin	136	32	24%
Kennebec	160	59	37%
Penobscot	200	53	27%
Somerset	68	25	37%
Waldo	115	40	35%
Washington	203	8	4%
York	146	5	3%
TOTAL	**1,447**	**319**	**22%**

Irrigated farms reporting

County	USDA 2012 irrigated farms	farms reporting an irrigated crop	percent of USDA irrigated farms
Androscoggin & Sagadahoc	158	26	16%
Aroostook	89	12	13%
Franklin	37	16	43%
Kennebec	90	13	14%
Penobscot	129	18	14%
Somerset	60	12	20%
Waldo	118	9	8%
Washington	75	6	8%
York	152	2	1%
TOTAL	**908**	**114**	**13%**

Survey results

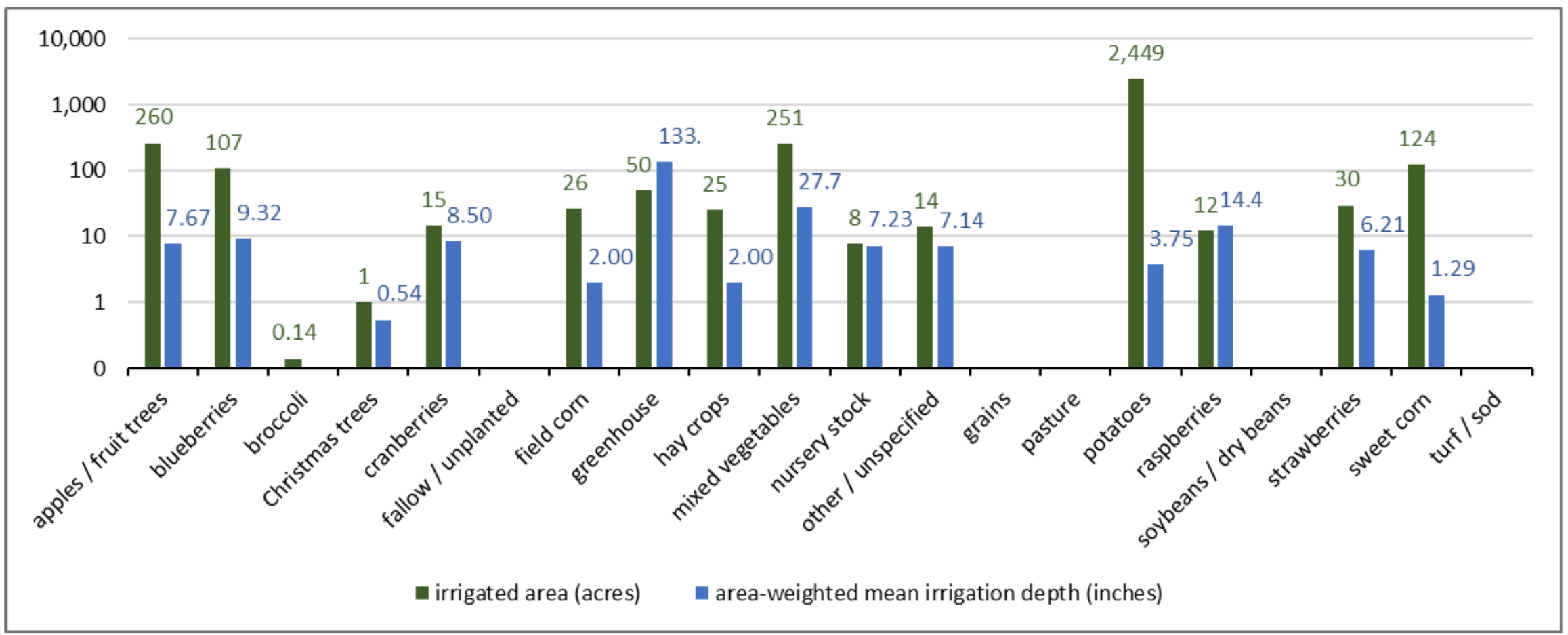
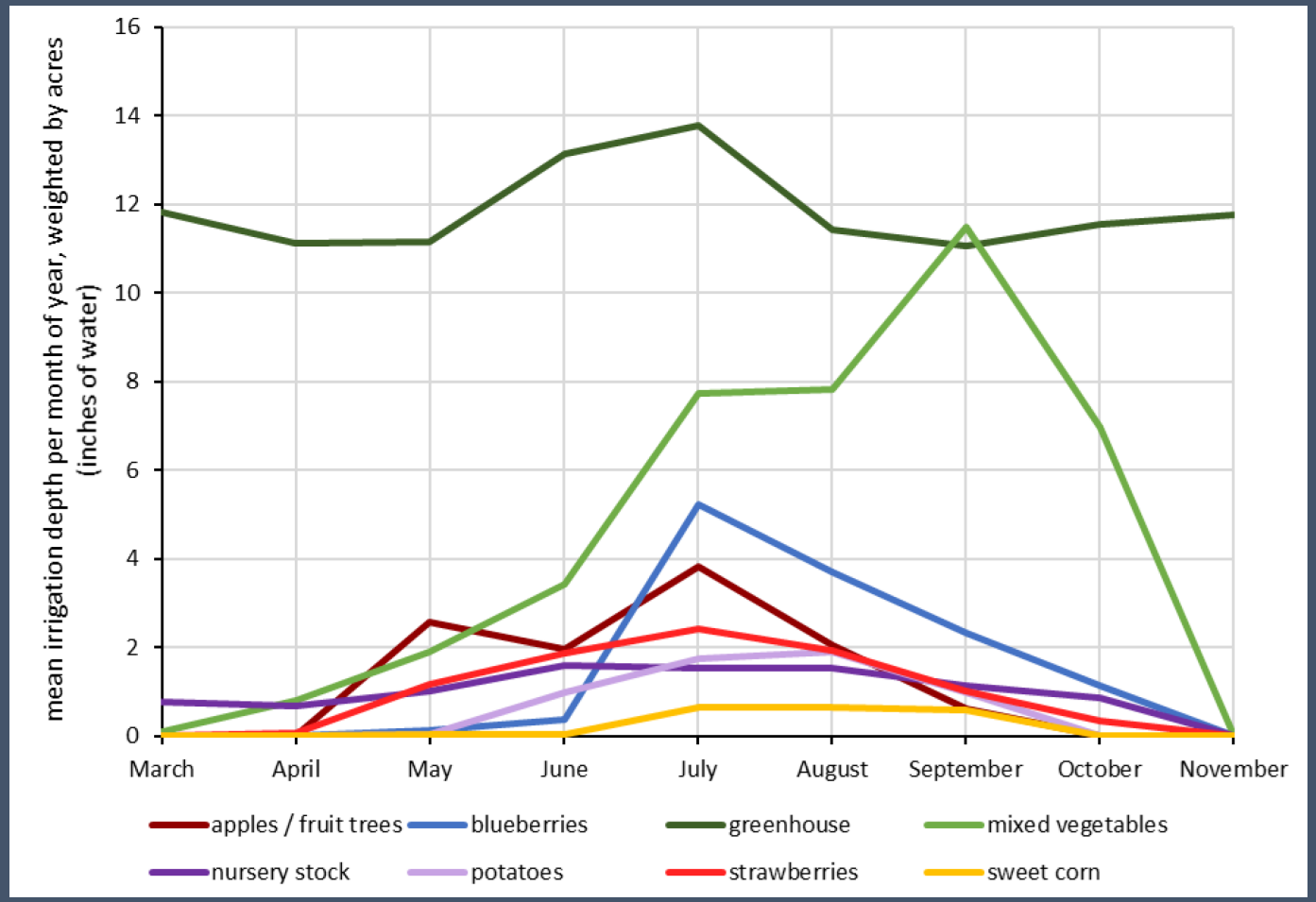
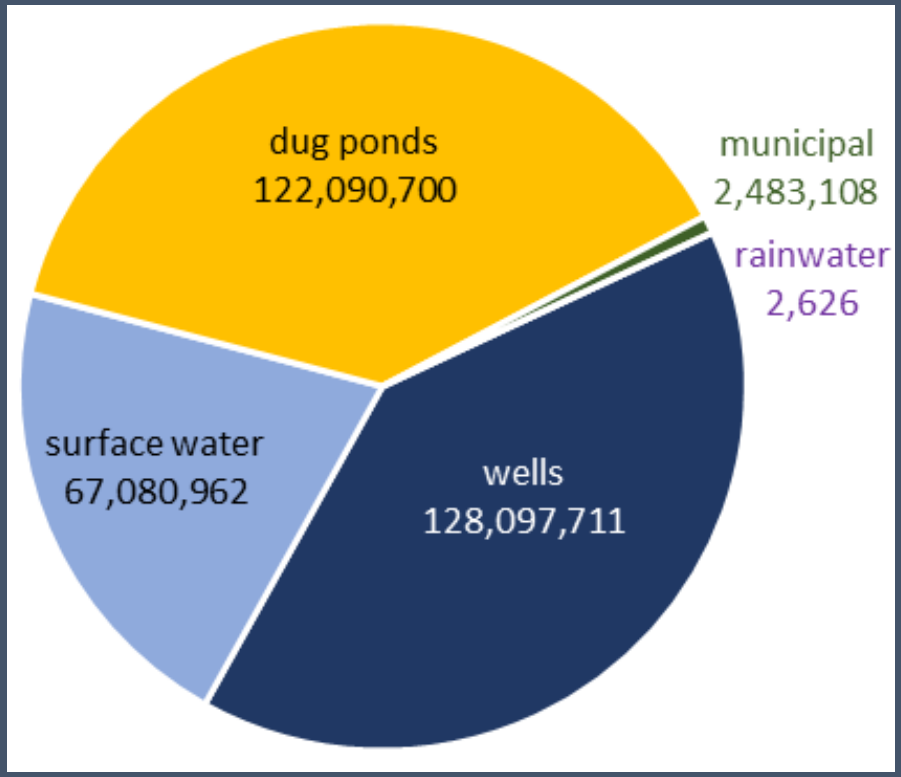


Figure 2. Total irrigated acres of each crop type reported by survey respondents, and area-weighted mean inches of water applied to each type of irrigated crop in all of 2016. Vertical axis scale is logarithmic.

Survey results

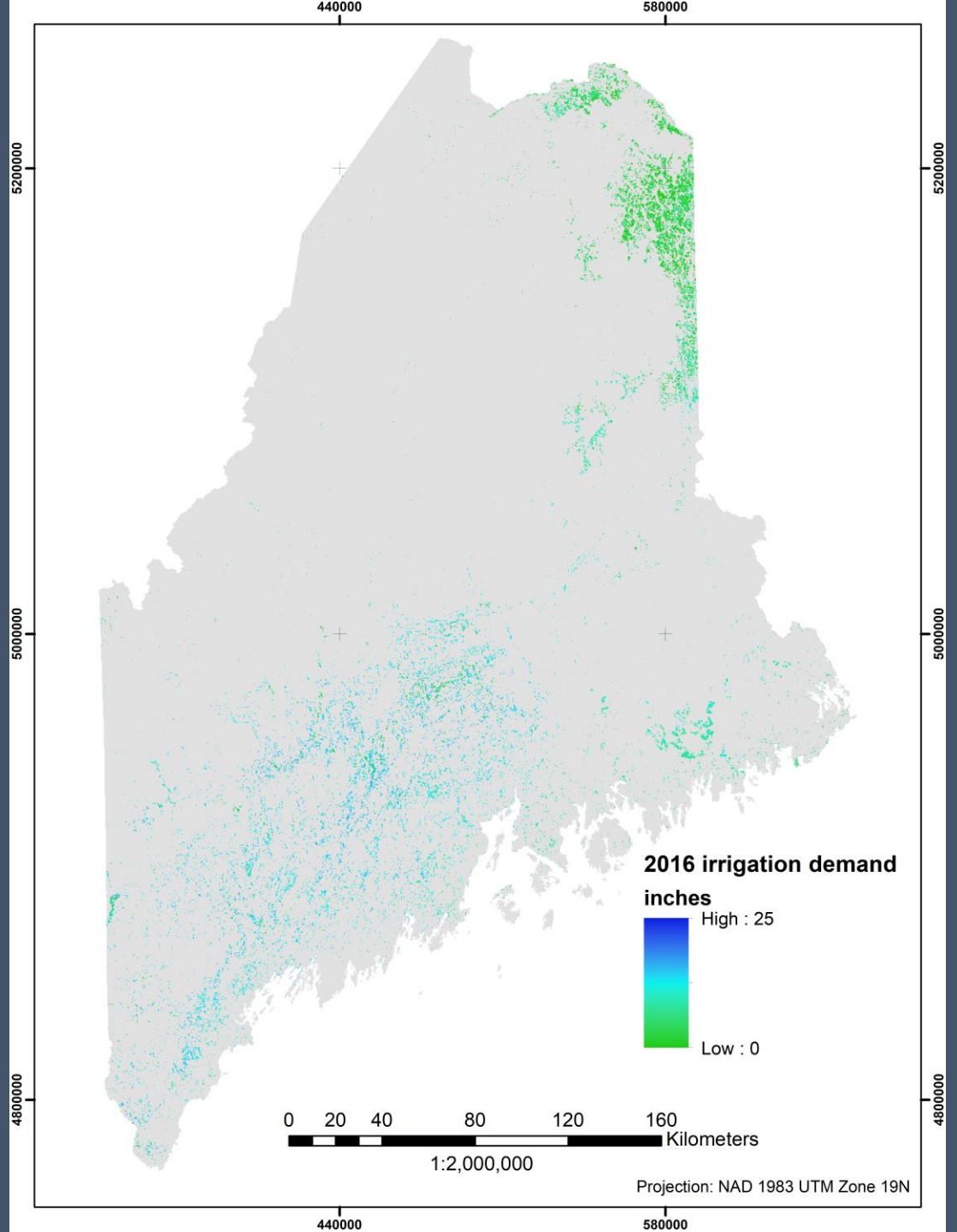


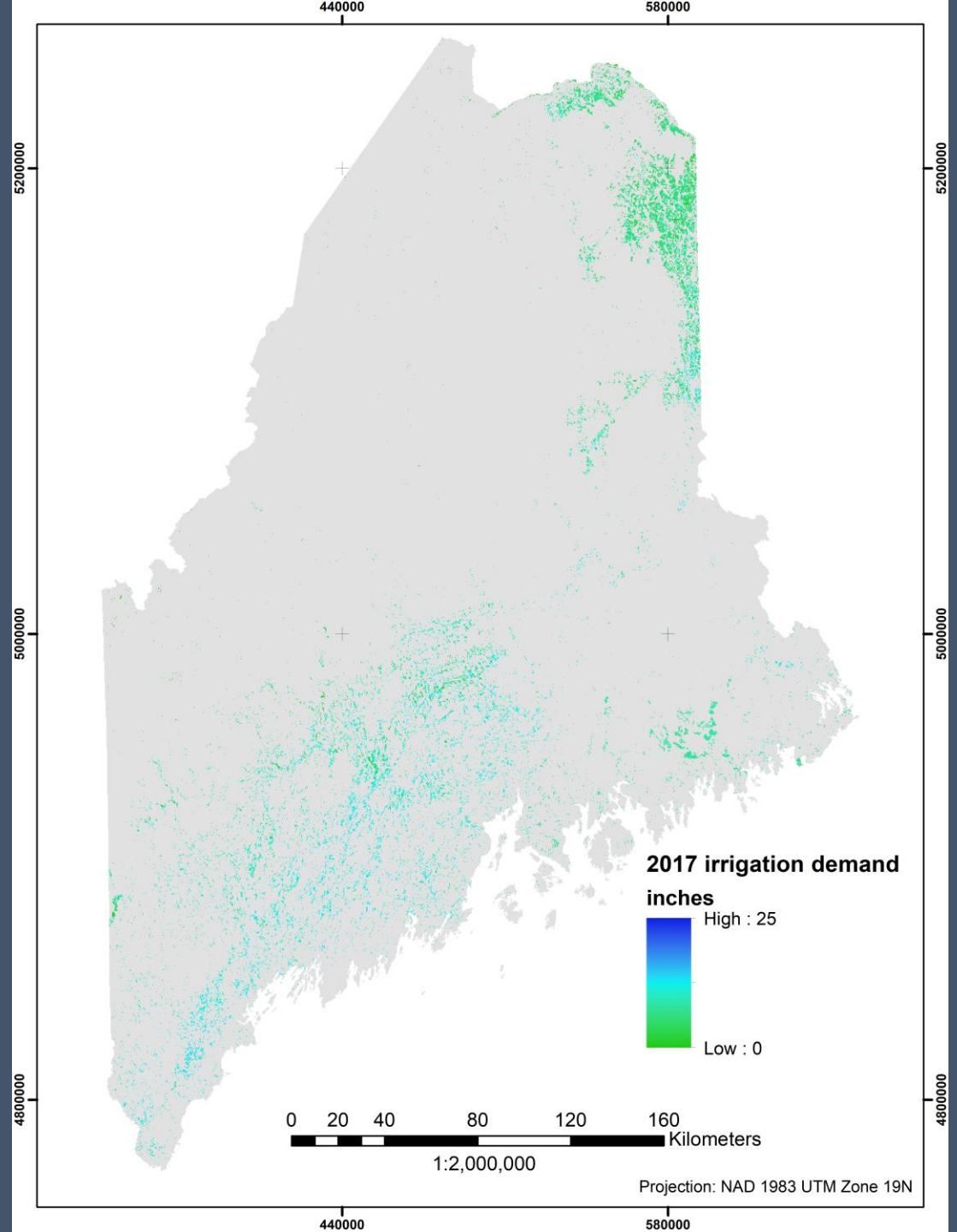


…and much more!

Ag Part 2: Irrigation Demand Model

- Uses the same underlying Soil Water Balance (SWB) Model code
  - Grid only defined in crop areas according to the USDA Cropland Data Layer
  - Additional module implementing the FAO-56 crop evapotranspiration method (Allen et al., 1998)
- Calibrated to both USDA Census of Ag (2013) and results of our ag survey (2016)
- Output consists of potential annual irrigation demand in inches
- Multiply the demand by the actual irrigated land area


440000
580000
5200000
5000000
4800000
2016 irrigation demand
inches
High : 25
Low : 0
0 20 40 80 120 160
Kilometers
1:2,000,000
Projection: NAD 1983 UTM Zone 19N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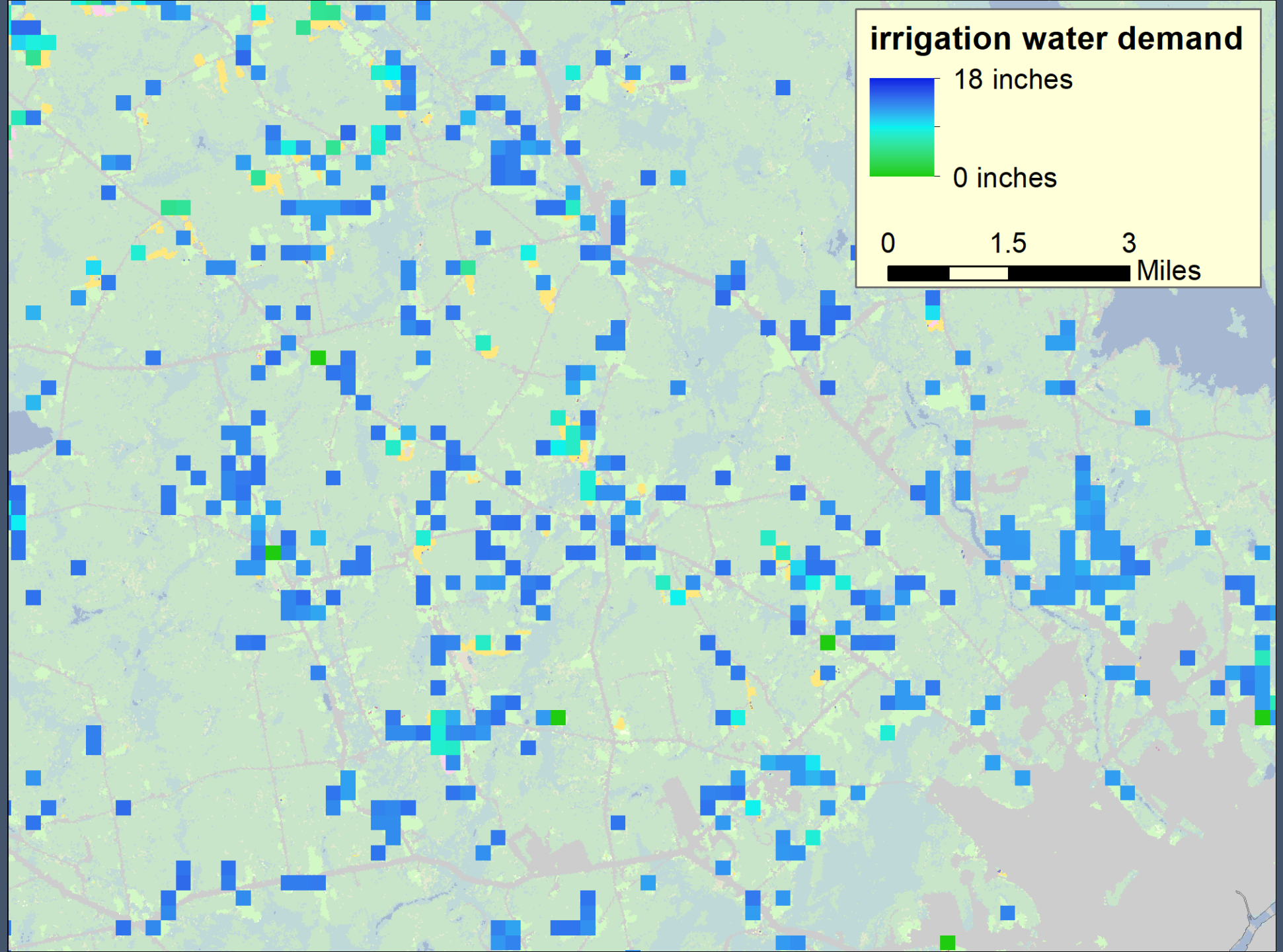
irrigation water demand
18 inches
0 inches
0
1.5
3
Miles

Irrigation water use estimates (Statewide)

Table A3. Statewide irrigation water application volume estimated in years 2013, 2016, and 2017, by crop type and in total. The estimated irrigated area of each crop in Maine is multiplied by the mean irrigation water demand depth from Table A1 to arrive at the total water volume for each crop.

		2013		2016		2017	
crop	irrigated acres	mean inches	million gallons	mean inches	million gallons	mean inches	million gallons
alfalfa	1,261	0.0	0.4	1.8	62	1.5	50
apples	490	5.8	77	16.8	223	13.0	173
blueberries	28,095	7.0	5,324	8.3	6,351	8.1	6,189
broccoli	3,600	3.8	374	3.6	351	5.2	504
Christmas trees	298	0.2	2	1.3	10	1.6	13
corn	1,023	1.4	39	2.9	81	2.6	72
cranberries	30	14.0	11		0		0
grains	1,388	0.4	16	0.9	32	3.9	146
grass/pasture	0	2.4	0	4.9	0	5.2	0
hay non alfalfa	0	7.4	0	12.8	0	10.9	0
misc fruits and vegs	369	9.6	97	12.4	125	13.7	137
potatoes	9,438	4.7	1,206	5.3	1,355	7.8	2,008
sod/grass seed	562	7.1	108	11.3	172	9.5	145
soybeans	0	3.4	0	5.8	0	7.7	0
sweet corn	451	1.0	12	3.9	48		0
TOTAL	**47,005**		**7,266**		**8,810**		**9,436**

Domestic and public supply water use

Ongoing WUDR project, completion in late 2020

Ongoing domestic water use work

1. Automated programmatic method for compiling and analyzing data from public water utilities (collaboration with the Maine PUC).
2. Population estimates for public water systems and self-supplied homes using utility network and population data.
3. Analyze patterns of use in billing data donated by a few water companies – develop per capita coefficients for domestic use.

Future work:
Watershed supply-and-demand analysis

- Will look at the balance between water supply (annual runoff) and demand (human use and minimum stream flows)
- The analysis will cover all 12-digit HUC watersheds in Maine
- A revision and update to the “watersheds-at-risk” analysis from 2006